APPENDIX B

FLASH FLOOD MANUAL

OF

LOCAL FLOOD FORECAST PROCEDURES

Appendix B is the Flash Flood Manual which contains forecast procedures or backup forecast procedures prepared for the county/community by the National Weather Service (NWS). This sample manual does not explicitly reference automated hydrometeorological sensors or personal computer base stations. It is based on the assumption that rain gages and stream gages are read by local observers and computations are manually performed. The extension of this manual to cover automated warning systems, however, should be straightforward. Chapters B-1 through B-4 of this Flash Flood Manual contain general information and instructions that pertain to all counties/communities. Chapter B-5 describes the flood problem(s) for a particular county/community and includes the forecast procedure(s) (table) developed for the county/community.

Chapter B-5 in this Appendix is an example for a fictitious community called Lake County. Chapters B-1 through B-4 are designed to be a part of an operational document for flood forecasting and can be separated or copied from this Handbook. Chapter B-5, containing actual forecast procedures for the specific county/community, would then complete an operational Flash Flood Manual.

FLASH FLOOD MANUAL

FOR THE

COUNTY/COMMUNITY OF

_____

APPENDIX B
FLASH FLOOD MANUAL
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TABLE OF CONTENTS (continued)

Note: Pages in Chapter 5 are included as necessary.

FLASH FLOOD MANUAL

CHAPTER B-1 - INTRODUCTION

This Flash Flood Manual is intended for use by Federal, state, and local offices. It consists of two major parts: the basic manual in Chapters 1, 2, 3, and 4; and the county/community-specific manual in Chapter 5. All pages in Chapter 5 would include the county/community name as part of the page identifier. An office that maintains manuals for several counties would have the basic manual (Chapters 1-4) plus a Chapter 5 for **each** county/community that it represents. Page identifiers on Flood Advisory Tables include both county and station name. More than one Flood Advisory Table may be included in Chapter 5 for a particular county/community.

1.1 Purpose

The purpose of this Flash Flood Manual is to establish NWS guidelines and procedures under which a county/community can forecast flash floods, thus enabling advance warnings to those communities located along small tributary streams.

1.2 Plan

A "Flood Warning Unit" will be organized consisting of a flood warning coordinator, communications support, gage network supervisor, rainfall and stream observers, and other support staff. This unit will work closely with Disaster Services Agency/Office of Emergency Services/Disaster and Emergency Services to ensure that advisories and warnings will produce effective and timely community action.

1.3 Organization

Community cooperation is the foundation of the Flood Warning Unit. Rain gages will be installed at specified sites (coordinated with problem areas) around the Local Flood Warning System (LFWS) area. The daily reading and maintenance of these gages will be the responsibility of local observers. Rainfall amounts will be reported by these observers to a designated local Flash Flood Coordinator, and this Coordinator will use the amounts to calculate the average precipitation over the area. Utilizing a procedure developed by the NWS River Forecast Center (RFC) to determine the threat for flash flooding, the Flash Flood Coordinator will notify the Disaster Services Agency Director if the potential of flash flooding exists or if flooding is imminent. The Coordinator must relay this same information to the NWS office having flood warning responsibility for the county. The structure of the LFWS is shown graphically in Figure 1, Section 1.4 below.

The responsibilities and relationship between the NWS and the local government for the LFWS is specified in a mutual agreement between the participating agencies. Several meetings between the local government and the NWS will be required to define the roles and responsibilities of each. The mutual agreement (Memorandum of Understanding) begins on page 5-20 of this Manual.

1.4 Structure

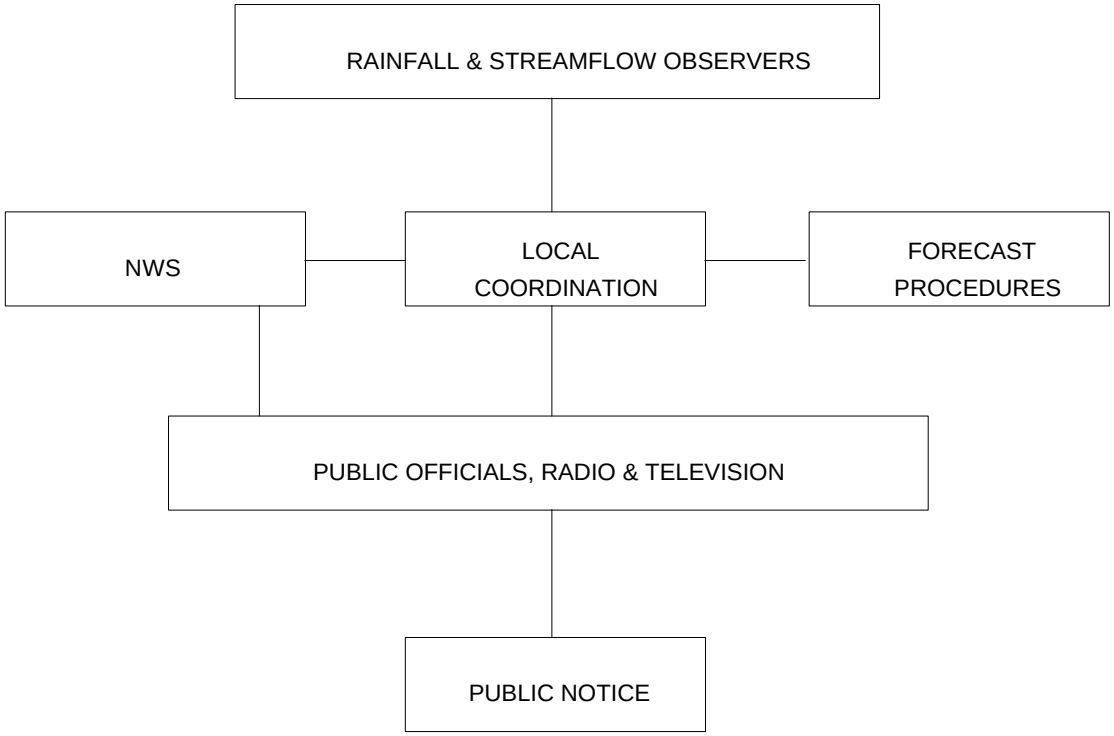

Figure 1. *Structure of typical flood warning system.*

1.5 Feedback

Cooperation at all levels of the program is the key to success of any flood warning system. The work of the local observer should go beyond reporting rainfall. If possible, observations should also include storm characteristics, stream response to rainfall, the time flooding begins and ends, time of flood crest, etc. The Flash Flood Coordinator should always be checking the effectiveness of the flood procedure which may have been developed by the NWS. The effectiveness of the procedure may relate to location, time of year, or storm characteristics. Close coordination with the Disaster and Emergency Services Agency will help refine community response to the warning system.

The importance of feedback to the NWS cannot be overstated. Through this feedback, present procedures can be maintained to better handle flash flood problems of the individual communities within the county.

FLASH FLOOD MANUAL

CHAPTER B-2 - HYDROLOGIC FORECASTING

2.1 Hydrologic Factors

In the application of the self-help hydrologic forecast procedures for floods and flash floods, the following information is needed:

1. The amount of water available for runoff. (This includes snowmelt as well as rainfall and is usually referred to as the average basin rainfall.)

2. A method of determining the amount of runoff produced. [The Advisory Table (or categorical procedure) relates rainfall to runoff for a location with the use of the current advisory rainfall (or flood guidance) and the runoff procedure.]

3. The length of time of rainfall which produces runoff (duration of significant rainfall).

4. The amount of water in the stream prior to a runoff-producing event.

5. Reservoir release changes from upstream reservoirs.

Items 1, 3, and 4 have to be measured or observed at the site. Item 2 has been incorporated into the forecast procedure and requires getting into the correct column in the Advisory Table. The advisory rainfall furnished to the user identifies the column to use. This value is updated and sent daily by the NWS RFC to the Weather Forecast Office (WFO). The WFO forwards the advisory rainfall to the Flood Warning Unit. Each forecast procedure has been developed specifically for the location stated thereon and should not be applied to any other site. This includes even localities situated on the same stream since hydrologic characteristics and gage datums are rarely identical at different locations. Item 5 is available from the agency who controls the upstream reservoir.

2.1.1 Determining the Amount of Rain

This is by far the most important factor needed in making a forecast and, of course, can come only from your precipitation network, including volunteer and automated gages. Therefore, it is your responsibility to see that all instructions for measuring and reporting precipitation are clearly understood and followed. Note that the word "precipitation" is used rather than "rainfall" because your network should also keep you informed of the amount of snow present, not only its depth but, of even greater importance, the amount of water in the snow. In hydrology, this is known as the "water content" of the snowpack and refers to the amount of water the snow will yield upon melting. The rate of the snow depth to the water equivalent of the same depth is generally 10:1. As the snow packs down, the density increases to two or three times this amount. In using the procedure when rain falls and snow is present on the ground, the water content of the snow should be added to the rainfall (see section 5.9); and the

total is used in making the forecast. This assumes that all the snow will either be washed down or melted with the rain. This is usually what happens; but, in those cases where this does not

The precipitation value used is the average for the entire basin not just the amount measured at a single station. The reason for this will soon become obvious with use, and you will probably

on the accuracy of any report that appears exceptionally low or exceptionally high. Also, it is a good idea to inquire as to the state of the present weather and the prospects for additional

of certain situations is to use future rain in forecasting rivers.

2.1.2

Quite often a moderate rainfall of 2 inches in January can cause a significant river rise, perhaps even a flood; yet, this same amount of rain in July may have little or no effect. The

different seasons of the year. The production of runoff is a complex natural process and is affected by many factors, the principal ones being the type of soil, its recent moisture history,

and seasonal rainfall patterns. The relationship of these factors to runoff productivity has been built into your procedures with the overall effect expressed in a number. This number is the

flooding at your location. The advisory rainfall designates the proper column to use in the Advisory Table.

Determining Runoff Duration

In order to better understand the mechanism involved in the rise and fall of a stream, consider

that water is running out at the bottom, the water level will not rise as long as the inflow does not exceed the outflow. However, if the inflow is increased so it exceeds the outflow, the

rate of rise increases. Decrease the rate of inflow below the rate of outflow and the water level falls. The principles illustrated here apply equally well in the rise and fall of a river. As the

(the rain slackens), the rate of rise decreases. If the rate of inflow decreases below the outflow rate, the river will fall even though the rain still continues. Now you can understand why the

This will also explain why there may be more than one crest since the river can start rising again after cresting if the rate of inflow again exceeds the rate of outflow, i.e., the rainfall

Define duration as the length of time from the beginning of runoff until the end of heavy rain. A good estimate will usually be satisfactory. The start of runoff can be obtained by noting when the river starts to rise. Duration is important because of its effect on the crest, both its height and time of occurrence. The relationship is inverse, i.e., as the duration increases, the length of time to crest after the end of heavy rain decreases. In cases of prolonged rainfall, the crest will be close to the end of heavy rain; and warning time may be zero. It is for this reason that we cannot always wait until the rain is measured before making a forecast. Accordingly, under certain conditions, the only practical way to provide warning time is to prepare forecasts ahead of or before the end of the rain event. Wording of the forecast should clearly indicate that rainfall has not yet occurred but may be likely or it has not yet ended. The forecast is worded, "The crest will be…feet if we get one inch of additional rain and…feet if we get two inches of additional rain."

2.1.4 Stream Level Before the Runoff Event

A typical stream that is prone to flash floods rises and falls within a short time of a runoff-producing event. Therefore, most of the time, the stream level is very low, and the amount of water in the stream is insignificant in comparison to the amount of water in the stream during a flood. However, some streams respond slower to runoff-producing events and may have a significant amount of water when another runoff-producing event occurs. In this situation, the current level of the stream must be included in a crest forecast. The reason for this is that all advisory rainfall and flood guidance assume the streams are at a low or insignificant flow. We refer to these low flows as base flows.

2.1.5 Adjustment for Upstream Reservoir Releases

If a reservoir is located upstream of your location, your crest forecast must be adjusted to reflect changes in releases from the reservoir. It is important to note that we said changes in releases. The current reservoir release is represented by the current stream level. Adjustment of your crest forecast for the current stream level was explained in Section 2.1.4 above.

Frequently, reservoir releases will be greatly reduced during or after a runoff-producing event to lessen the severity of flooding downstream. At times, such action can eliminate downstream flooding. If there are any reservoirs in your system, your crest forecast must be adjusted to reflect any changes in upstream reservoir releases. The amount of the adjustment is the difference between the release prior to runoff and the release at the time of the expected crest. The time of the expected crest is specified in your Advisory Table. The reservoir release at the expected time of crest will be available from the agency that operates the reservoir. Timing of the reservoir releases is critical to your crest forecast as you will learn from a few events. A good working relationship with the agency responsible for operation of the reservoir would be beneficial. If no changes in releases are planned after a runoff-producing event, you do not adjust your crest forecast.

2.2

The following information is needed to make a crest forecast using a Flood Advisory Table or a Categorical Procedure:

Average basin rainfall for the area of concern. (This is the amount of water available for runoff and includes snowmelt as well as rainfall.)

Advisory rainfall or flood guidance for the area. (This is available from the NWS. These values are an indicator of soil moisture and are derived from a history of storms

the RFC.)

3.

4. Base flow. This is the amount of water in the stream before the rain occurred.

Reservoir release changes. (If a reservoir is located upstream, any changes in releases must be considered to obtain a crest forecast.)

Flash Flood Watches, Warnings, and Internal Affairs

1.

NWS office any time you feel a watch may be necessary.

2.

3. Based on your reports of heavy rain and/or flooding relayed to the NWS office

precipitation estimates, the NWS will issue a FLASH FLOOD WARNING for your county (see example #1 below). However, if you cannot contact the NWS, time is

local WARNING (see example #2 below). Every effort should be made to notify the NWS as soon as possible after the warning is issued.

Example #1:

SAMPLE FLASH FLOOD WARNING ISSUED BY
NATIONAL WEATHER SERVICE

The National Weather Service has issued a Flash Flood Warning effective until 5 p.m., Sunday, for _____ County, _____(state).

A Flash Flood Warning means flooding is imminent. Take necessary precautions as required.

Heavy rains have been falling over much of the county with gage reports and radar precipitation estimates indicating almost four inches in western parts of the county…radar indicates additional heavy thunderstorms southwest of the county and more heavy rains are likely this afternoon…

This additional rainfall will produce local flooding.

Persons near areas that are prone to flooding should be on the alert for fast-rising waters.

* *

Example #2

SAMPLE FLASH FLOOD WARNING ISSUED BY
LOCAL DISASTER AND EMERGENCY SERVICES AGENCY

_____ Disaster and Emergency Services Agency has issued a Flash Flood Warning for _____ County until 5 p.m. this afternoon. Heavy rains over the area through 3 p.m. this afternoon have caused rises on the small streams and creeks throughout the county. Unless the rain ends shortly, significant flooding of small streams and creeks is likely. All interests along rivers and streams in the area should take immediate life-saving action and keep alert for later statements on the FLOOD SITUATION.

FLASH FLOOD MANUAL

CHAPTER B-3 - SMALL STREAM FORECASTS

3.1 Description of Categorical Forecasts

The categorical forecasts of flooding used in this manual can be interpreted by the following terminology :

Degree of Flooding	General Description
Minor	Near flood stage—only minimal damage expected.
Moderate	Secondary roads blocked—transfer to higher elevations necessary to save property. Some evacuations may be required.
Major	Extensive inundation and damage—many primary roads and bridges closed. Many people may be evacuated.

The amount of runoff needed to cause these “levels” of flooding are incorporated in the small stream forecast procedures.

3.2 Sample Categorical Forecast Procedure

GENERALIZED FORECAST PROCEDURE FOR UNGAGED STREAMS

CATEGORY	RUNOFF INCHES	AVERAGE BASIN RAINFALL (INCHES) FOR TIME DURATION OF GUIDANCE USED											
MINOR	0.25	0.5	0.6	0.7	0.8	1.1	1.2	1.4	1.8	2.2	2.6	3.1	3.6
GUIDANCE	0.50	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	3.5	4.0	4.5
	0.75	1.1	1.3	1.5	1.8	2.1	2.4	2.6	3.1	3.6	4.1	4.5	5.0
	1.00	1.4	1.6	1.8	2.1	2.5	2.8	3.0	3.5	4.0	4.5	5.0	5.5
MODERATE	1.25	1.7	1.9	2.1	2.4	2.8	3.1	3.3	3.8	4.4	4.9	5.3	5.8
	1.50	1.9	2.1	2.4	2.7	3.1	3.3	3.6	4.1	4.7	5.2	5.6	6.1
	1.75	2.2	2.4	2.6	3.0	3.4	3.6	3.9	4.4	5.0	5.5	5.9	6.4
----------	2.00----	2.4	2.7	2.9	3.3	3.7	3.9	4.2	4.8	5.3	5.8	6.3	6.7
	2.25	2.7	2.9	3.2	3.5	4.0	4.2	4.5	5.0	5.6	6.1	6.5	7.0
	2.50	3.0	3.2	3.5	3.8	4.2	4.5	4.8	5.3	5.9	6.3	6.8	7.2
MAJOR	2.75	3.2	3.5	3.7	4.1	4.5	4.8	5.1	5.6	6.1	6.6	7.1	7.5
	3.00	3.5	3.7	4.0	4.4	4.8	5.1	5.4	5.9	6.4	6.9	7.4	7.8
	3.25	3.7	4.0	4.3	4.6	5.1	5.4	5.6	6.2	6.7	7.2	7.6	8.0
	3.50	4.0	4.3	4.5	4.9	5.4	5.7	5.9	6.5	7.0	7.4	7.9	8.3
	3.75	4.3	4.5	4.8	5.2	5.6	5.9	6.2	6.8	7.2	7.7	8.1	8.6
	4.00	4.5	4.8	5.1	5.5	5.9	6.2	6.5	7.0	7.5	8.0	8.4	8.8
	4.25	4.8	5.0	5.3	5.7	6.2	6.5	6.7	7.3	7.8	8.2	8.7	9.1
	4.50	5.0	5.3	5.6	6.0	6.4	6.7	7.0	7.5	8.0	8.5	8.9	9.3
	4.75	5.3	5.6	5.8	6.2	6.7	7.0	7.2	7.8	8.3	8.7	9.2	9.6
	5.00	5.6	5.8	6.1	6.5	6.9	7.2	7.5	8.0	8.5	9.0	9.4	9.8
	5.25	5.8	6.1	6.3	6.7	7.2	7.5	7.7	8.3	8.8	9.2	9.7	10.1
	5.50	6.1	6.3	6.6	7.0	7.5	7.7	8.0	8.6	9.0	9.5	9.9	10.3

3.3 Instructions for Use of Categorical Forecast Procedure

Follow steps 1 through 5 under section 4.1, "Instructions for Using the Advisory Table."

3.4 Examples of Categorical Forecasts

EXAMPLE #1 **Rainfall Tabulation**

Guidance from NWS for 9/15
1 Hour: 1.0
3 Hour: 1.2
6 Hour: 1.5
12 Hour: 2.0

Date/Time	9/15				REMARKS
LOCATION	7 AM				
#1	3.10				Heavy rainfall occurring over about 4 hours
#2	2.88				
#3	3.24				
#4	2.95				
#5	3.01				
Total Rainfall	15.18				
Average (/5)	3.04				
Guidance (NWS)	1.2				Use 3-hour guidance
Degree of Flooding	Major				

EXAMPLE #2 **Rainfall Tabulation**

Guidance from NWS for 10/15
1 Hour: 1.1
3 Hour: 1.3
6 Hour: 1.6
12 Hour: 2.0

Date/Time	10/15				REMARKS
LOCATION	10 PM				
#1	2.16				Heavy rainfall occurring over about 5 hours
#2	2.42				
#3	1.89				
#4	1.97				
#5	2.07				
Total Rainfall	10.51				
Average (/5)	2.10				
Guidance (NWS)	1.6				Use 6-hour guidance
Degree of Flooding	Moderate				

CHAPTER B-4 - SITE-SPECIFIC (HEADWATER) FORECASTS

4.1 Instructions for Using the Advisory Table

Steps to follow when using the Advisory Table in Section 4.2 to arrive at a crest forecast (or categorical forecast):

1. Obtain the flood guidance (a measure of soil moisture conditions) from the NWS office which has guidance responsibility for your community.

2. Determine the observed rainfall for the basin and the duration of rain (hours). When several rain gages are located in or near the basin, average these values to obtain the average basin rainfall, which becomes the observed rainfall to use in the Advisory Table (categorical procedure).

3. Select guidance corresponding to the proper duration of continuous rain or nearest duration if between two values. For instance, if the observed rainfall duration was 5 hours, use guidance for 6 hours. If the duration was 4 hours, use guidance for 3 hours instead of for 6 hours.

4. Enter the table at the line labeled flood stage, "FS," (or guidance) and move to the right to the guidance value selected in Step 3. You may need to estimate between columns if the guidance does not match a column. Move up or down in this column until the observed basin rainfall is found. You may need to estimate between rows.

5. Move to the left along the same row containing the observed basin rainfall to the column labeled "Discharge" for a gaged stream. This value is the discharge or flow you can expect from the rainfall just observed. (For an ungaged stream, using the table in Section B-3.2, move to the column labeled "Category" and extract the categorical forecast. End of categorical procedure.)

6. If this is a gaged stream and you have been reading the river gage, you have an idea of the discharge which, in low water conditions, is referred to as base flow; otherwise, go to Step 9. Enter the far left column labeled "Stage Feet" and move down to the river gage reading. Then move right to the next column and read the discharge. This is the base flow.

7. Obtain releases from any reservoirs upstream of gage location. Determine the increment of change in releases. (Increment of change will be zero if releases are the same as previous value.) ONLY THE INCREMENT OF CHANGE IS USED TO SUM THE TOTAL FLOW/DISCHARGE. Reservoir release values are given in cubic feet per second (cfs).

8. Add the discharge from Step 5 to the base flow in Step 6 and the increment of change in reservoir releases in Step 7. This new summed value becomes the total discharge of

the expected crest in cubic feet per second.

9. Enter the column labeled "Discharge" (second column from the left) and find the discharge of the expected crest. Move to the left to the stage column and read the stage to the nearest foot or one-half foot. This is the crest stage. Refer to the notes above the table to determine when the crest will occur.

4.2 Sample of Flood Advisory Table

EXAMPLE FLOOD ADVISORY TABLE ANYTOWN MUDDY R

FLOOD STAGE 6.0 FT FLOOD OF RECORD 11.70 FT 01/22/59
DRAINAGE AREA 175 SQ MI GAGE DATUM 610.30 FT MSL

CREST ABOUT 10 HOURS AFTER HEAVY RAIN ENDS.

EXAMPLE

MAXIMUM HEIGHT 12.9 FT ON 3/04/48 BACKWATER FROM ICE.

STAGE FEET	DISCHARGE 1000 CFS	AVERAGE BASIN RAINFALL (INCHES) FOR TIME DURATION OF GUIDANCE USED												
3.0	0.4	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.9	1.2	1.4	1.7	2.1	2.6
3.5	0.6	0.1	0.3	0.4	0.4	0.5	0.6	0.7	1.0	1.4	1.7	1.9	2.5	2.9
4.0	0.8	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.2	1.6	1.9	2.3	2.8	3.4
4.5	1.2	0.3	0.4	0.6	0.7	0.8	0.9	1.1	1.4	1.9	2.3	2.7	3.3	3.8
5.0	1.6	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.7	2.2	2.7	3.2	3.7	4.2
5.5	2.2	0.6	0.7	0.9	1.1	1.4	1.5	1.6	2.1	2.5	3.0	3.5	4.1	4.6
FS 6.0	2.9	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	3.5	4.0	4.5	5.0
6.5	3.6	0.9	1.2	1.4	1.6	1.8	2.0	2.3	2.8	3.3	3.8	4.3	4.8	5.3
7.0	4.3	1.1	1.4	1.6	1.8	2.0	2.2	2.4	3.0	3.5	4.1	4.6	5.1	5.6
7.5	5.3	1.4	1.6	1.8	2.0	2.3	2.5	2.7	3.3	3.8	4.4	4.9	5.4	5.9
8.0	6.4	1.6	1.9	2.1	2.3	2.6	2.8	3.1	3.6	4.2	4.7	5.2	5.8	6.3
8.5	7.4	1.9	2.2	2.4	2.6	2.9	3.1	3.4	4.0	4.5	5.0	5.5	6.1	6.6
9.0	8.5	2.2	2.5	2.7	2.9	3.2	3.4	3.7	4.3	4.8	5.4	5.9	6.4	6.9
9.5	9.7	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.7	5.2	5.7	6.2	6.8	7.2
10.0	11.0	2.8	3.1	3.4	3.6	3.9	4.2	4.4	5.0	5.6	6.1	6.6	7.1	7.6
10.5	12.5	3.2	3.5	3.8	4.0	4.3	4.6	4.9	5.5	6.1	6.6	7.0	7.6	8.0
11.0	14.2	3.6	4.0	4.2	4.5	4.7	5.0	5.3	6.0	6.5	7.0	7.5	8.0	8.4
11.5	16.0	4.1	4.5	4.7	5.0	5.2	5.5	5.8	6.5	7.0	7.5	8.0	8.5	8.9
12.0	18.0	4.6	5.0	5.2	5.5	5.8	6.1	6.3	7.0	7.5	8.0	8.5	9.0	9.4

3 HR UNITGRAPH PEAK ORDINATE = 3900.CFS FLOOD STAGE R.O. = 0.75

4.3 Examples on Use of Advisory Tables

Example

Guidance from NWS for:

Example 1	3 hr: 1.2 6 hr: 1.6 12 hr: 2.0	Excessive Rainfall Duration is 3 hours; therefore, use the 3-hour guidance value.
Example 2	3 hr: 2.1 6 hr: 3.0 12 hr: 3.8	Excessive Rainfall Duration is 5 hours; therefore, use the 6-hour guidance value.
Example 3	3 hr: 2.0 6 hr: 3.0 12 hr: 4.5	Excessive Rainfall Duration is 10 hours; therefore, use the 12-hour guidance value.

For Anytown, Muddy River
Example

DATA:	#1	#2	#3
Guidance	1.2	3.0	4.5
River Stage	4.0	3.5	3.0
Observed Rainfall Data:			
Gage 1	2.21	2.75	3.05
Gage 2	2.34	3.08	2.98
Gage 3	2.57	2.88	3.24
Gage 4	2.41	2.94	3.12
Total Rainfall	9.53	11.64	12.39
Average	2.38	2.91	3.10
Flow/discharge from rainfall	7400	2800	1000
Flow/discharge from base flow	800	600	400
Releases from reservoir (increment of change)	500	-1000	0
Total flow/discharge	8700	2400	1400
FORECAST:			
Crest Stage in Table	9.1 ft	5.6 ft	4.8 ft
Crest Stage Issued	NEAR 9.5 FT	NEAR 6 FT	NEAR 5 FT

FLASH FLOOD MANUAL

CHAPTER B-5 - LAKE COUNTY (SAMPLE)

HYDROLOGIC FORECAST PROCEDURES

This chapter is structured to discuss the following topics as they relate to the sample flash flood locality called Lake County:

Note: Pages in this section are included as necessary.

5.1 Problem Streams

Heavy rainfall can cause any small stream to overflow its banks. Some streams and creeks in the county are more flood prone than others due to topographic features and continuing development along the streams. The following list summarizes the problem streams in the county:

Name of Stream	Flood Problem Location
Brush Creek	In Maple City between Main and Broadway
Black River	In Maple City along Knoll Avenue and Lee Avenue east of Lake Drive

5.2 Area Description

Lake County has an average annual precipitation of approximately 40 inches. Monthly precipitation is distributed fairly evenly during the year; May and June are the wettest months; October is the driest month.

Flash floods can occur during any season but are more prevalent during prolonged periods of rain with a large, sudden burst of heavy rain usually associated with thunderstorms. The average number of thunderstorms is about 20 per year. Maximum temperatures average in the mid-30s °F in January to near 80 °F in July. Minimum temperatures average in the low 20s °F in January to the mid-60s °F in July. Average winter season snowfall is about 15 inches with greater amounts at higher elevations. Flash floods from a combination of snowmelt and rainfall can pose a problem during this season.

5.3 Past Floods

DATE	CREST	REMARKS	DATE	CREST	REMARKS

5.4 Instructions for the Flash Flood Coordinator

The Flash Flood Coordinator is the focal point for the flood warning system. Preplanned action is required to make the flood warning system operate successfully to achieve its goal—reducing the loss of lives and personal property due to the destructiveness of floods and flash floods.

Specific tasks of the Flash Flood Coordinator are as follows:

1. Using the flash flood procedure to analyze all storm events to determine the potential for flash flooding.

2. Contacting the NWS if the flash flood procedure indicates flooding or if flooding has been reported. The NWS will issue the flash flood warning. If time is critical, the Flash Flood Coordinator should issue a warning through designated county officials THEN contact the NWS.

3. Keeping the Disaster Emergency Services Director and the NWS informed on all pertinent weather and flash flood information.

4. Maintaining contact with local observers to verify flooding, to obtain data, and/or to inform observers of recent developments.

5. Recruiting, organizing, and training volunteer rainfall and stream gage observers.

At the end of each month, the rainfall observers are instructed to mail two copies of the observation form to the Flash Flood Coordinator (WS Form E-16, "RECORD OF RAINFALL REPORTER" may be used and copies obtained from the NWS, see section 5.9.1, or a locally prepared form). One copy is retained in county files; the other copy is for NWS files. When all observers have sent their observation forms in to their county, the Coordinator must forward one copy from each observer to the following address:

_____

_____

_____

_____

_____

5.5 Support Agencies and Flash Flood Warning Staff Members

The County is responsible for maintaining an up-to-date list of contact persons from their support agencies as well as all staff members.

5.5.1 Support Agencies

	Name	Title/Agency	Telephone No.
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			

5.5.2 Flash Flood Warning Staff Members

	Name	Title/Agency	Telephone No.
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			

5.6 Flash Flood Warning List

The County is responsible for maintaining an up-to-date list of contact persons in the event a flash flood warning is issued.

	Name	Agency	Telephone No.
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			

5.7 Map of Streams and Observer Locations

[Reserved for map]

5.8 Rain and Stream Gage Network Observers

The placement of any rain gage is dependent on the size and shape of the drainage basin, local topography, accessibility of the gage, and the availability of a responsible observer.

	Name of Creek	Name of Observer	Location/Address	Telephone No.
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				

5.9 Instructions for Rainfall Observers

Introduction

The rainfall observers' responsibilities are to read, record, and report the amount of precipitation that falls in their areas. Prompt reports are extremely important to the effectiveness of the Flood Warning System.

Observations

A **daily** observation should be taken (usually about 7 a.m.). Empty the rain gage at this time. Special observations are taken during periods of heavy rainfall. See items 2 and 3 below in "WHEN" to report by telephone or radio.

If snow has fallen, the snow should be melted to obtain the water equivalent as described on the next page.

Recording the Observation

Enter all observations in the appropriate columns on the recording form. Total snow depth on the ground should be recorded in the remarks column, if necessary.

Report by Telephone or Radio

WHEN:

1. At 7 a.m., if *x* inch (or more) of rain was observed during the winter months (November-April) or *y* inch (or more) during the summer months (May-October). The amount “x” and “y” amount of rain should be defined by the local flash flood coordinator in coordination with the NWS.

2. At any other time if less than the reporting amount in item 1 above was observed at 7 a.m. but the rain continues and the total storm rainfall (7 a.m. plus additional rainfall) equals or exceeds the reporting amount in item 1.

3. At any time each additional amount (equal to the reporting amount in item 1 above) accumulates as the rain continues.

4. Occurrence of any of the following SEVERE weather:

    A. Tornado or funnel cloud;
    B. Damaging winds that uproot trees and/or damage buildings;
    C. Hail (dime-size or larger);
    D. Flooding that begins to cover roads or causes evacuation; and
    E. Freezing rain.

WHAT:

1. Your name and location or station.

2. Amount of rain in your gage at last observation.

3. Amount of rain in your gage at the last 7 a.m. observation if not reported previously. **REMEMBER--EMPTY GAGE ONLY AT 7 a.m.**

4. Type of SEVERE weather (if any).

TO:

Flood Coordinator: _____

or Assistant 1: _____

or Assistant 2: _____

or, as a last resort, the National Weather Service at the following location:

_____

_____

_____

Wintertime Operation

During low temperatures when freezing will occur, remove the funnel and center measuring tube. (The tube breaks easily when water freezes inside it.) Place them in a safe and convenient location because the measuring tube will still be needed. Frozen precipitation caught by the outer tube must be melted and poured into the measuring tube to measure the water content of the frozen precipitation. This can be done by two different methods:

1. Place the outer tube with the frozen precipitation in it near a source of heat—NOT ON IT—and let stand until the frozen precipitation has melted. Then pour the liquid into the measuring tube and read the amount.

2. Fill the center measuring tube with warm water to the 0.50-inch line. Pour this on the frozen precipitation in the outer tube. Place the funnel on the measuring tube and carefully pour the liquid in the outer tube back into the measuring tube. Read the amount and subtract 0.50 inch from it to obtain the water content of the frozen precipitation.

Water Equivalent (Liquid Content) of Snow on the Ground

This is the amount of water in the snow and/or ice on the ground. It becomes very important when above-freezing temperature is expected along with rain.

Press the outer tube of the rain gage top down into a level area of snow. Slip a thin piece of material, such as aluminum, beneath the mouth of the outer tube to hold the sample in as you withdraw the outer tube from the snow. Cut and remove the samples in layers when the depth of snow to be sampled is deeper than the outer tube. Make the cut where the sample will represent the average snowfall and where the snow cover seems least affected by drifting. (Obtain several samples to get a more representative liquid content.)

Melt and measure the samples as described above for wintertime operation. Record the water content on the record form and include the content in the 7 a.m. report.

Gage Exposure

Mount the rain gage in a convenient location. Ideally, the gage should be mounted on a sturdy post in an open area away from buildings or trees. The top of the gage should extend about 6 inches above the top of the post; the gage should be level.

Operation of the Rain Gage

The funnel catches the rain and delivers it to the measuring tube. The measuring tube in the 4-inch diameter (11-inch depth) plastic gage will hold 1 inch of rain. Rainfalls of less than 1 inch can be read directly on the measuring tube to the nearest 0.01 inch. Rainfalls exceeding 1 inch will overflow the measuring tube and collect in the outer tube. To measure, empty the measuring tube containing the first inch. Place the funnel into the empty measuring tube and carefully pour the contents of the outer tube into the measuring tube. Repeat the pouring and emptying until the outer tube is empty. Be sure you add 1 inch each time you empty a full measuring tube. It is a good idea to measure heavy rainfalls twice to ensure accuracy. Just use an empty can or pan to pour the water into, then measure again.

5.9.1 WS Form E-16

WS FORM E-16 (12-72) PRES. BY WSOM E-41

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN
NATIONAL WEATHER SERVICE

RECORD OF RAINFALL REPORTER

STATION

RIVER DRAINAGE

TYPE OF RAINGAGE

MONTH | YEAR | TIME OF OBSERVATION

DATE	PRECIPITATION				REMARKS (Special observations, etc.) E
	BEGAN A	ENDED B	24-HOUR AMOUNT C	CHARACTER D	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					

NOTE: Send this form to Supervising Office monthly.

SUPERVISING OFFICE

REPORTER

WS FORM E-16 (12-72)

☆ U.S. Government Printing Office: 1979—668-127

Record of Rainfall Reporter

Station - Name of your town and state.

River Drainage - Stream for which warnings are issued based on your rainfall reports. If no particular stream, leave blank.

Month, Year - Be sure to enter these.

Time of Observation - Time you usually take daily reading.

Type of Rain Gage - Most are plastic 11" Clear-Vue.

Began, Ended - The time precipitation began and ended is *not required* and is difficult to keep track of. If you do know the times, especially of heavy rainfall, you may enter them here or in remarks.

24-Hour Amount - The amount of precipitation that fell in the 24-hour period ending with your observation time. For example, the entry at 8 a.m. on the 6th would cover the 24 hours from 8 a.m. on the 5th to 8 a.m. on the 6th. In the winter, any snow, sleet, etc., must be melted and figured in with any rain that fell. Enter precipitation in inches and hundredths of an inch (e.g., 0.07, 0.26, 1.09, 2.67). Use the following:

0 - No precipitation in the last 24 hours.

T - Trace—it rained but there was too little to measure, less than 0.01 inch.

M - Missing—you could not read the gage that day.

MAKE AN ENTRY EVERY DAY.

Character - *Not required.* If you wish, enter rain, snow, hail, etc.

Remarks - Special readings and those called to the Flood Coordinator are important. Unusual or severe weather and flooding should be reported.

Supervising Office - Your county.

Reporter - Your name.

KEEP A COPY OF YOUR RECORDS AND AT THE END OF EACH MONTH SEND THE REQUIRED NUMBER OF COPIES TO YOUR COORDINATOR.

5.10 Small Stream Forecasts

5.10.1 Categorical Forecast Procedure

GENERALIZED FORECAST PROCEDURE FOR SMALL STREAMS

CATEGORY	RUNOFF INCHES	AVERAGE BASIN RAINFALL (INCHES) FOR TIME DURATION OF GUIDANCE USED											
MINOR	0.25	0.4	0.5	0.6	0.7	0.8	1.0	1.4	1.8	2.1	2.5	3.1	3.6
	0.50	0.7	0.9	1.1	1.3	1.4	1.5	1.9	2.4	2.9	3.4	4.0	4.5
GUIDANCE	0.75	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	3.5	4.0	4.5	5.0
	1.00	1.3	1.5	1.7	1.9	2.1	2.4	2.9	3.4	3.9	4.4	5.0	5.5
	1.25	1.5	1.7	2.0	2.1	2.4	2.6	3.2	3.7	4.2	4.8	5.3	5.8
MODERATE	1.50	1.8	2.0	2.2	2.4	2.7	2.9	3.5	4.1	4.6	5.1	5.6	6.1
	1.75	2.0	2.3	2.5	2.7	3.0	3.2	3.8	4.4	4.9	5.4	5.9	6.4
	2.00	2.3	2.5	2.8	3.0	3.3	3.5	4.1	4.7	5.2	5.7	6.2	6.7
	2.25	2.5	2.8	3.0	3.2	3.5	3.8	4.4	5.0	5.5	6.0	6.5	7.0
	2.50	2.8	3.1	3.3	3.5	3.8	4.1	4.7	5.3	5.7	6.3	6.8	7.2
MAJOR	2.75	3.1	3.3	3.6	3.8	4.1	4.4	5.0	5.5	6.0	6.5	7.1	7.5
	3.00	3.3	3.6	3.8	4.1	4.4	4.7	5.3	5.8	6.3	6.8	7.3	7.8
	3.25	3.6	3.8	4.1	4.3	4.6	4.9	5.6	6.1	6.6	7.1	7.6	8.0
	3.50	3.8	4.1	4.4	4.6	4.9	5.2	5.8	6.4	6.9	7.3	7.9	8.3
	3.75	4.1	4.4	4.6	4.9	5.2	5.5	6.1	6.7	7.1	7.6	8.1	8.6
	4.00	4.3	4.6	4.9	5.1	5.5	5.7	6.4	7.0	7.4	7.9	8.4	8.8
	4.25	4.6	4.9	5.2	5.4	5.7	6.0	6.6	7.2	7.7	8.1	8.6	9.1
	4.50	4.9	5.1	5.4	5.6	6.0	6.3	6.9	7.5	7.9	8.4	8.9	9.3
	4.75	5.1	5.4	5.7	5.9	6.2	6.5	7.1	7.7	8.2	8.6	9.1	9.6
	5.00	5.4	5.7	5.9	6.2	6.5	6.8	7.4	8.0	8.4	8.9	9.4	9.8
	5.25	5.7	5.9	6.2	6.4	6.7	7.0	7.7	8.2	8.7	9.1	9.6	10.1
	5.50	5.9	6.2	6.4	6.7	7.0	7.3	7.9	8.5	8.9	9.4	9.9	10.3

5.10.2 Categorical Forecast Worksheet

	Date/Time				
Location					**Remarks**
#1					
#2					
#3					
#4					
#5					
#6					
#7					
#8					
#9					
#10					
#11					
#12					
TOTAL RAINFALL					
AVERAGE BASIN RAINFALL					
GUIDANCE (NWS)					
DEGREE OF FLOOD					

Average basin rainfall = Total Rainfall/# observations

5.10.3 Storm Record for Categorical Forecasts

Date	Location/Creek	Guidance	Basin Average Rainfall	Degree of Flood

5.11 Site-Specific Forecasts

5.11.1 Flood Advisory Table

MAPLE CITY BRUSH CR

FLOOD STAGE 13.0 FT FLOOD OF RECORD 24.54 FT 08/13/80
DRAINAGE AREA 406 SQ MI GAGE DATUM 772.34 FT MSL

CREST ABOUT 10 HOURS AFTER HEAVY RAIN ENDS

STAGE FEET	DISCHARGE 1000 CFS	AVERAGE BASIN RAINFALL (INCHES) FOR TIME DURATION OF GUIDANCE USED												
2.0	0.1	0.0	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.7	0.9	1.1	1.3	1.6
3.0	0.2	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.7	1.0	1.2	1.5	1.8	2.2
4.0	0.4	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.3	1.5	1.8	2.3	2.8
5.0	0.7	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.1	1.5	1.8	2.1	2.7	3.2
6.0	0.9	0.2	0.4	0.5	0.6	0.7	0.8	0.9	1.3	1.7	2.1	2.5	3.0	3.5
7.0	1.1	0.3	0.4	0.6	0.7	0.8	0.9	1.1	1.5	1.9	2.3	2.8	3.3	3.9
8.0	1.3	0.4	0.5	0.7	0.8	1.0	1.1	1.2	1.6	2.1	2.6	3.0	3.6	4.1
9.0	1.6	0.5	0.6	0.8	0.9	1.1	1.3	1.4	1.8	2.2	2.7	3.2	3.8	4.3
10.0	1.9	0.5	0.7	0.9	1.1	1.3	1.4	1.6	2.0	2.4	2.9	3.4	4.0	4.5
11.0	2.1	0.6	0.8	1.0	1.2	1.4	1.6	1.7	2.1	2.6	3.1	3.6	4.2	4.7
12.0	2.4	0.7	0.9	1.1	1.3	1.5	1.7	1.8	2.3	2.8	3.3	3.8	4.3	4.8
FS13.0	2.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	3.5	4.0	4.5	5.0
14.0	3.0	0.9	1.2	1.3	1.5	1.7	1.9	2.2	2.7	3.2	3.7	4.2	4.7	5.2
15.0	3.4	1.0	1.2	1.4	1.6	1.8	2.0	2.3	2.8	3.3	3.9	4.4	4.9	5.4
16.0	3.8	1.1	1.3	1.5	1.7	1.9	2.2	2.4	3.0	3.5	4.0	4.5	5.0	5.6
17.0	4.2	1.2	1.5	1.6	1.8	2.1	2.3	2.5	3.1	3.6	4.1	4.7	5.2	5.7
18.0	4.9	1.4	1.7	1.9	2.1	2.3	2.5	2.8	3.3	3.9	4.4	4.9	5.4	6.0
19.0	5.7	1.6	1.9	2.1	2.3	2.5	2.8	3.0	3.6	4.2	4.7	5.2	5.7	6.2
20.0	6.6	1.9	2.1	2.3	2.6	2.8	3.1	3.3	3.9	4.5	5.0	5.5	6.0	6.5
21.0	7.5	2.2	2.4	2.6	2.9	3.1	3.4	3.6	4.2	4.8	5.3	5.8	6.3	6.9
22.0	8.6	2.4	2.7	2.9	3.2	3.4	3.7	4.0	4.6	5.1	5.6	6.2	6.7	7.2
23.0	9.7	2.8	3.0	3.3	3.5	3.8	4.0	4.3	4.9	5.5	6.0	6.5	7.0	7.5
24.0	11.6	3.3	3.6	3.8	4.1	4.4	4.6	4.9	5.6	6.1	6.6	7.1	7.6	8.1
25.0	13.9	4.0	4.3	4.5	4.8	5.1	5.4	5.6	6.3	6.9	7.3	7.8	8.3	8.8
26.0	15.6	4.5	4.8	5.0	5.3	5.6	5.9	6.1	6.8	7.4	7.8	8.3	8.8	9.3

3 HR UNITGRAPH PEAK ORDINATE = 3500.CFS FLOOD STAGE R.O. = 0.77

xxRFC 9/91

5.11.2 Advisory Table Forecast Worksheet

WORKSHEET FOR: Maple City, Brush Cr (SAMPLE)

	Date/Time					
Guidance (from NWS)						
River Stage						
Observed Rainfall:						
Gage 1						
Gage 2						
Gage 3						
Gage 4						
Gage 5						
Gage 6						
Gage 7						
Gage 8						
Gage 9						
Gage 10						
Gage 11						
Total Rainfall						
Average Basin Rainfall						
Flow/Discharge from Rainfall						
Flow/Discharge from Base Flow						
Incremental Changes Reservoir						
Total flow/Discharge						
FORECAST:						
Crest Stage in Table						
Crest Stage Issued						
Time of Crest Stage						

5.11.3 Storm Record for Advisory Table Forecasts

STATION: Maple City, Brush Cr (SAMPLE)

DATE	GUIDANCE	BASIN AVERAGE RAINFALL	FORECAST CREST STAGE	ACTUAL CREST STAGE	REMARKS

5.12 Memorandum of Understanding

A completed sample of the Memorandum of Understanding follows and completes Chapter 5 of this Appendix (see also samples in Appendix A). This sample Memorandum of Understanding contains the core responsibilities of both the Cooperator and NWS. Additional responsibilities must be included as described in Weather Service Operations Manual Chapter E-40.

SAMPLE
MEMORANDUM OF UNDERSTANDING
FOR A
MANUAL LOCAL FLOOD WARNING SYSTEM

This Memorandum of Understanding (MOU) between the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) and Lake County (Cooperator) is undertaken for the development and operation of a manual Local Flood Warning System (LFWS).

1. Authority

The NWS undertakes this MOU pursuant to its authority in 15 U.S.C. Section 313 and 7 U.S.C. Section 450b in order to carry out its functions relating to flood warnings.

2. Nature of Agreement

The Cooperator and the NWS agree to a program for the installation and operation of a manual LFWS for Lake County (community, area, or basin).

3. Responsibilities of the Cooperator

A. Ensure development and operation of an emergency response plan prior to or concurrent with the execution of this MOU that includes:

- coordination with the NWS and
- dissemination of warnings to the public.

B. Arrange for volunteer network observers.

C. Install, operate, and maintain the manual LFWS including:

- emergency operations center and
- equipment used to support the Cooperator's program including staff gages and plastic rain gages.

D. Designate, by name or position, who shall act for the Cooperator as the local representative.

E. Review annually with the NWS this MOU and the response plan. Update as necessary.

F. Conduct an annual drill, in coordination with the NWS, to test the system.

G. Monitor the manual LFWS and immediately notify the NWS of any significant program problems.

H. Relay NWS flash flood/flood watches, warnings, and statements to the public.

I. Establish an emergency operations center for the purpose of:

- receiving and recording all reports of rainfall and flood conditions;
- promptly relaying or making available all such reports to the designated Cooperator's representative;
- serving as the official distribution point for all warnings and statements issued by or for the designated Cooperator's Flood Warning Coordinator. When emergency conditions and lack of time prevent warnings being issued by the NWS, the designated local official(s) shall be prepared to issue appropriate warnings;
- ensuring that, in addition to general public distribution, flood warnings or statements reach warning action points as listed in the Cooperator's response plan;
- relaying river and rainfall reports, flood data, and warnings to the WFO Lake City NWS office as soon as practicable after local requirements have been satisfied.

4. Responsibilities of the National Weather Service

A. Assist in selection of equipment appropriate to the manual LFWS.

B. Provide assistance in rain and river gage site location.

C. Develop a self-help forecasting procedure as data become available for specific drainage basins and provide a copy to the Cooperator officials along with instructions for its use.

D. Utilize data from the manual LFWS and provide hydrometeorological forecast and warning service for the area served by the manual LFWS.

E. Provide appropriate warning distribution over NOAA Weather Wire Service and/or other NOAA product dissemination systems.

F. Provide training for the Cooperator's flash flood coordinators and local authorities (including network observers). The scope of the training covers:

- the NWS flood/flash flood watch/warning program,
- local flood warning programs,
- the need for emergency response planning,
- how to establish and maintain observer networks, and
- periodic drills to test the system.

G. Conduct an annual drill, in coordination with the Cooperator, to test the system.

5. Amendments and Modifications

This MOU may be amended or modified by mutual agreement of the NWS and the Cooperator. Additional responsibilities by either party are listed on an Addendum attached hereto and made a part hereof.

6. Termination

This MOU may be terminated by either party upon sixty (60) days written notice to the other party, notice to begin with date of mailing.

7. Effective Date

This MOU becomes effective on the date of the last signature shown below upon execution by the parties hereto.

Cooperator	National Weather Service
BY: Jane Brown	BY: Joseph Smith
TITLE: Mayor, Lake County	TITLE: Regional Director
DATE: May 3, 1996	DATE: May 10, 1996